Quantifying "Significant" Environmental Effects to Wells and Wetlands Using Surface Water and Groundwater Modeling

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BARR

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Barr Wetlands/Geologic/Hydrogeological Team

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Key takeaways

- Not all potential environmental effects are “significant” in the context of MN Rules Chapter 4410
- Stakeholders tend to assume that <u>any</u> effect has an impact
- Model forecasts of water table decline from the “baseline” can be confusing at water bodies/wetlands
- Results more straightforward in addressing impact to wells from project
- Using water balance method allows for clarity in understanding the change in flux to water bodies-potential effects more tangible
- Models can demonstrate that an effect with presumed impact can be plausibly mitigated-therefore the effect cannot be “significant” per rules

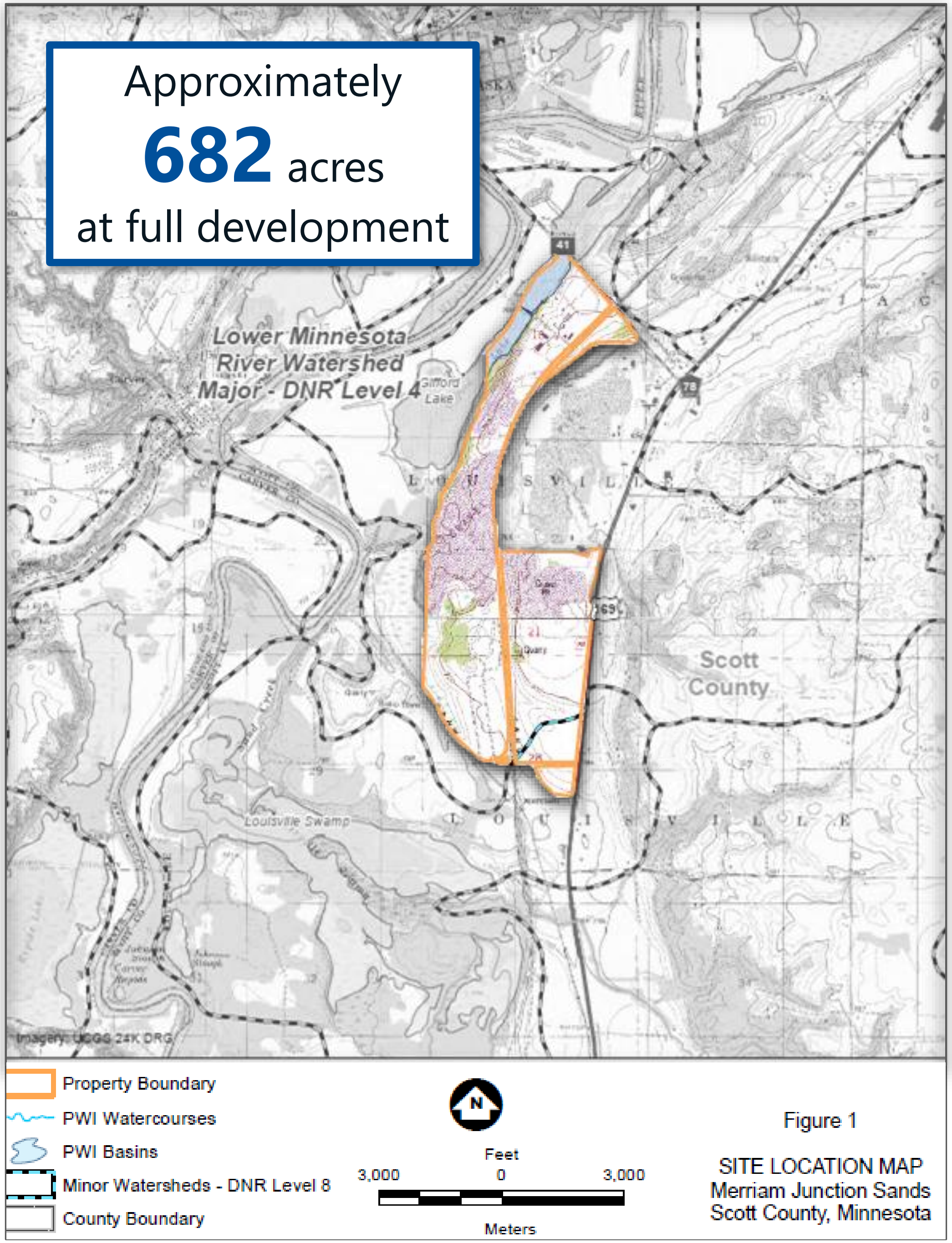
Outline

- Introduction and background – Terms: what is a “significant” environmental effect?
- Methods
- How groundwater models are typically used to predict environmental effects for projects – drawdown at water well example
- Discuss results and what is a “significant” environmental effect for dewatering near waterbodies like wetlands, lakes, and rivers.
- Summary

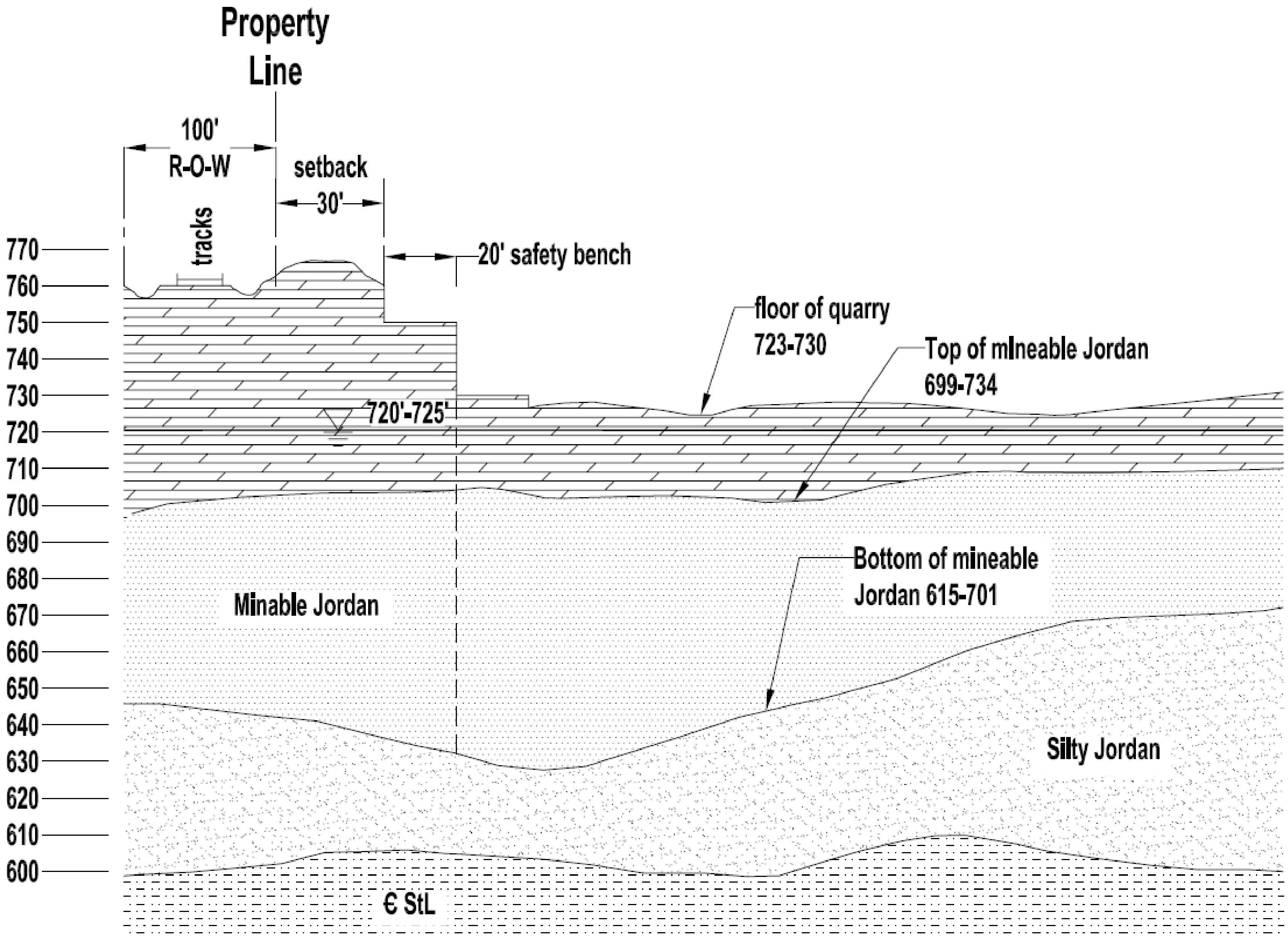
Background

Timeline

- 2011 **Initial field work and modeling**
- 2012 **New ownership group**
- 2015 **Modeling continues**
- 2017 **Frac sand market crashes; project proceeds**
- 2019 **Final modeling completed**
- July 2020 **Scott Board Decision of Adequacy**



Background: mineable deposits



- Historical mine area
- 1.2 mty/50-year deposit
- Sustainable mine plan
- Minimal dewatering
- Dry mining in dolostone first
- Hydraulic dredging into sandstone
- Complex phasing
- Reclamation: primarily open water

Background:
environmental review/permitting for aggregate mining

- National Environmental Policy Act and MN Rules 4410
  - Intent: provide information for public and decision makers on environmental aspects of a proposed project
- Projects with potential for **significant** adverse environmental effects that require further analysis during an EIS
- Scoping Environmental Assessment Worksheet (SEAW)
- Environmental Impact Statement (EIS)
- Permitting – Interim Use Plan (vs CUP)
- Mine Development-adaptive management, monitoring, and mitigation

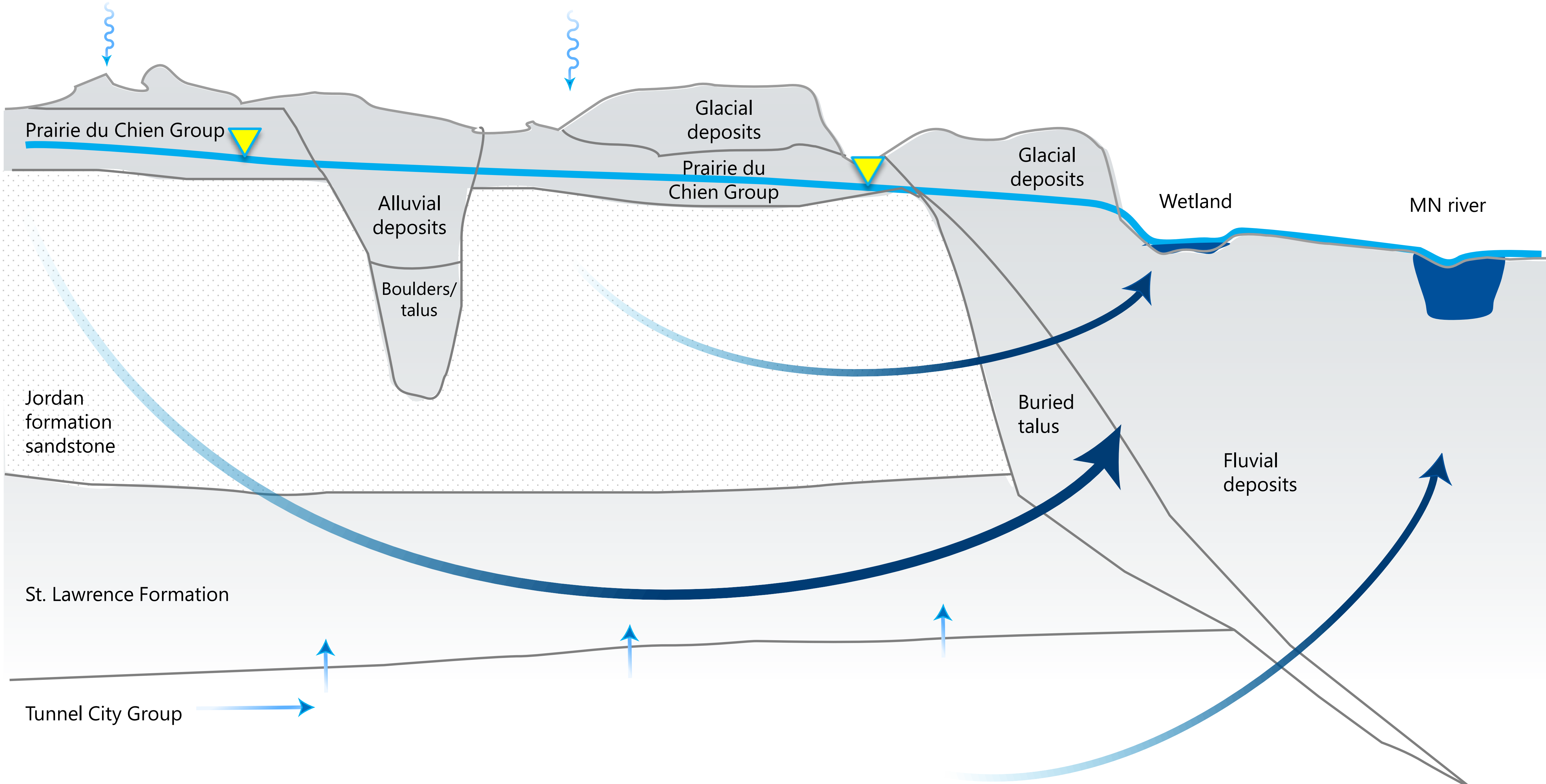
Terms (see *4410.1700 "DECISION ON NEED FOR EIS'*)

Effect	Significant	Impact
any measurable change due to a project	means there is an adverse environmental effect that can't be reversed, regulated or mitigated	our unofficial shorthand for the result of an adverse effect that would otherwise be significant (unless can be reversed, regulated or mitigated- not to be confused with "cumulative impacts")

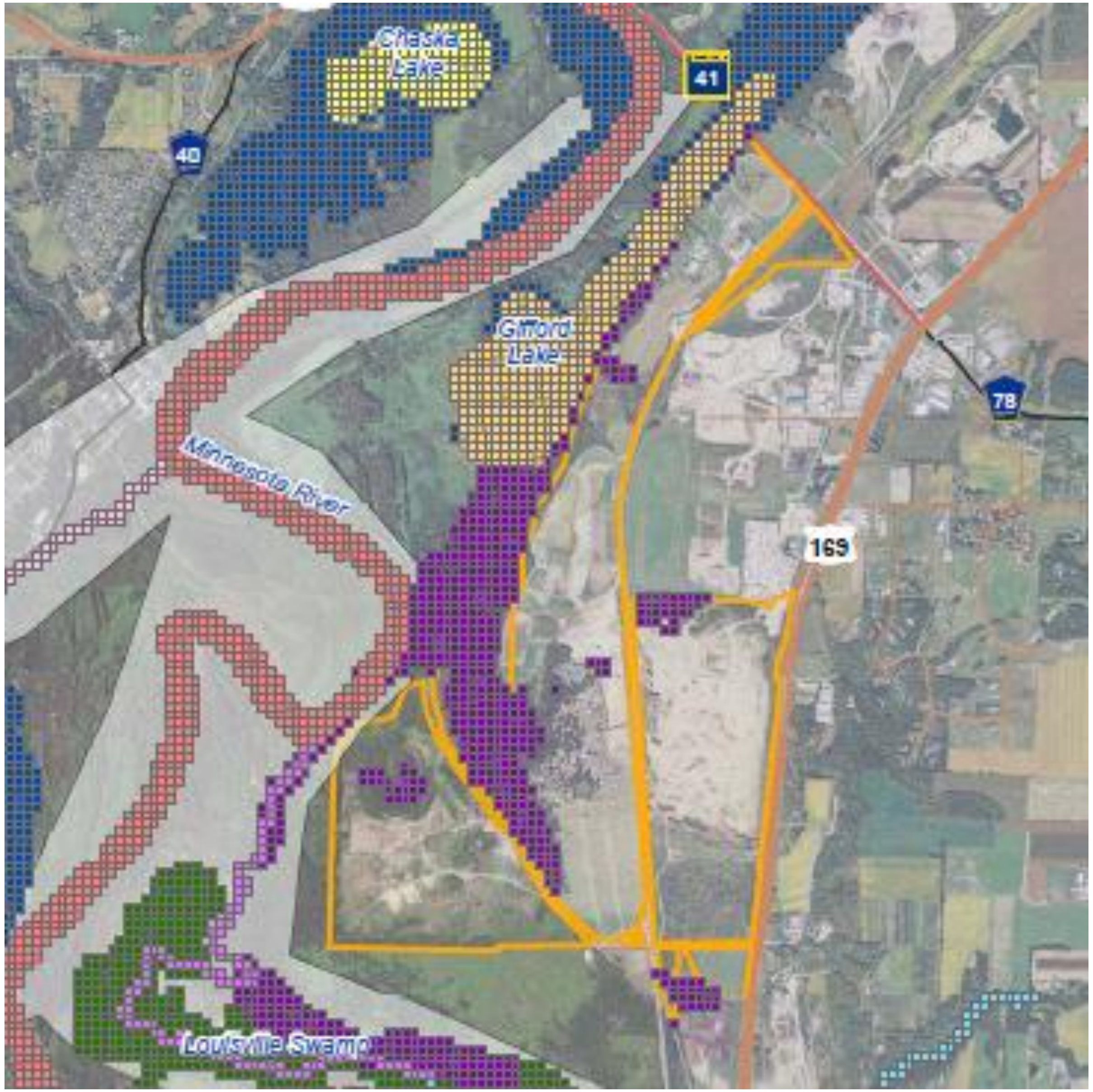
Model development: scope of groundwater assessment

Characterize site geology	**Rotasonic pilot borings, geophysics, ISO testing, MWI logs, and MGS data**
Characterize hydraulic properties	**Two pumping tests**
Characterize groundwater flow patterns and geochemical properties	**Static water level monitoring, water quality sampling**
Characterize connectivity of groundwater in Jordan to the groundwater in the wetlands	**Wetland stilling wells and piezometers**

Conceptual site model

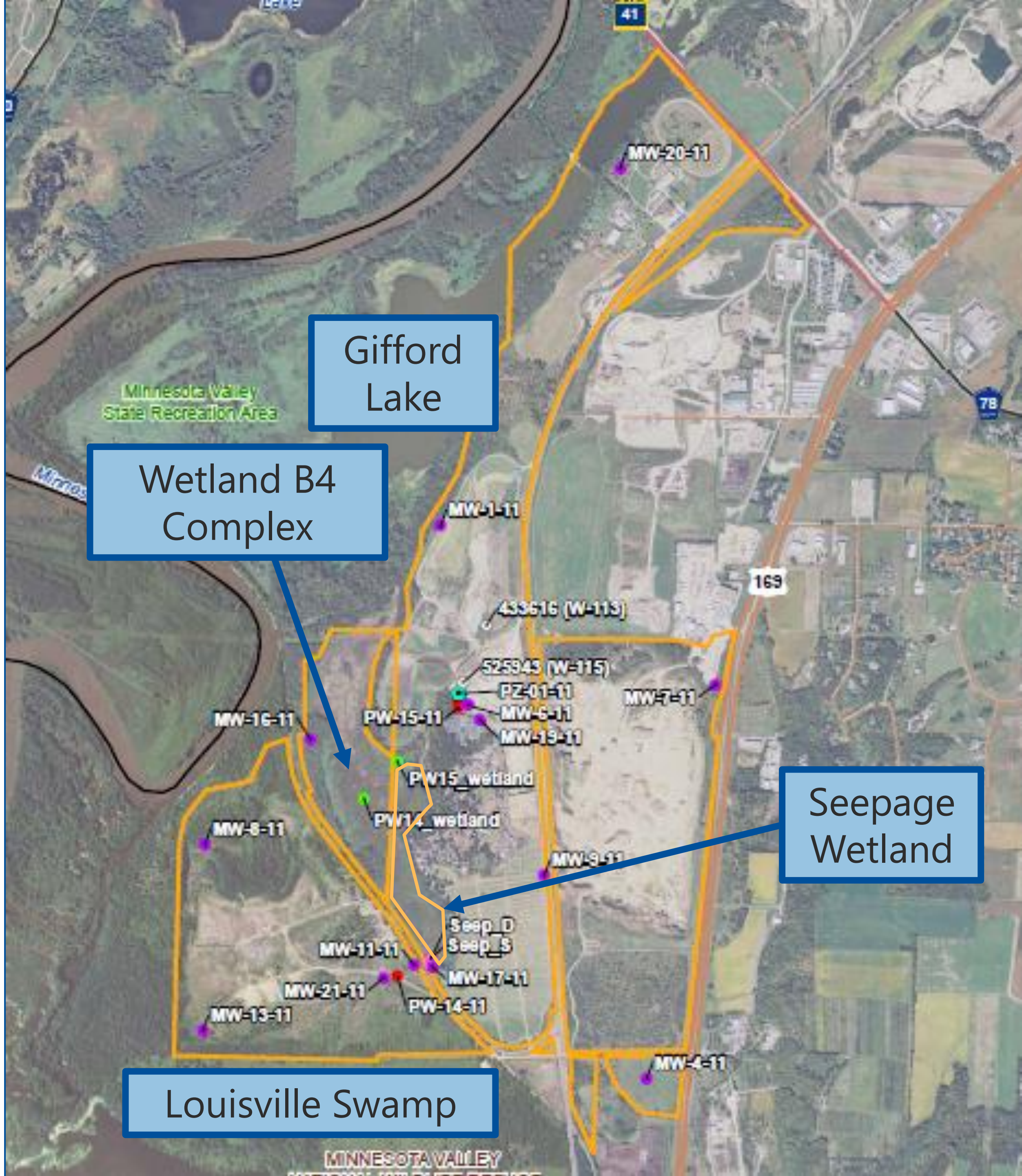


Groundwater flow model



- Steady state model-conservative (MODFLOW-NWT 2011)
- Refined from Metro Model 2 (Met Council, 2008)
- River Package and Drain Package for Wetlands
- Baseline groundwater data-initially 2 years but kept collecting more
- Calibrated to local and regional head data - weighted by proximity
- Pumping test data
- Inverse parameterization (PEST v12.1)
- Typical output is head or flux

Water resources



Surface water model (XP-SWMM)

- **XP SWMM** – 2D hydraulics and flood model
- **Purpose** – determine flood elevations, particularly Louisville Swamp
- **Findings** – all of the water bodies are “flow through” to or from the river
- **Distinction** – seepage wetland (Fresh Meadow and Shrub Carr complex) rarely inundated

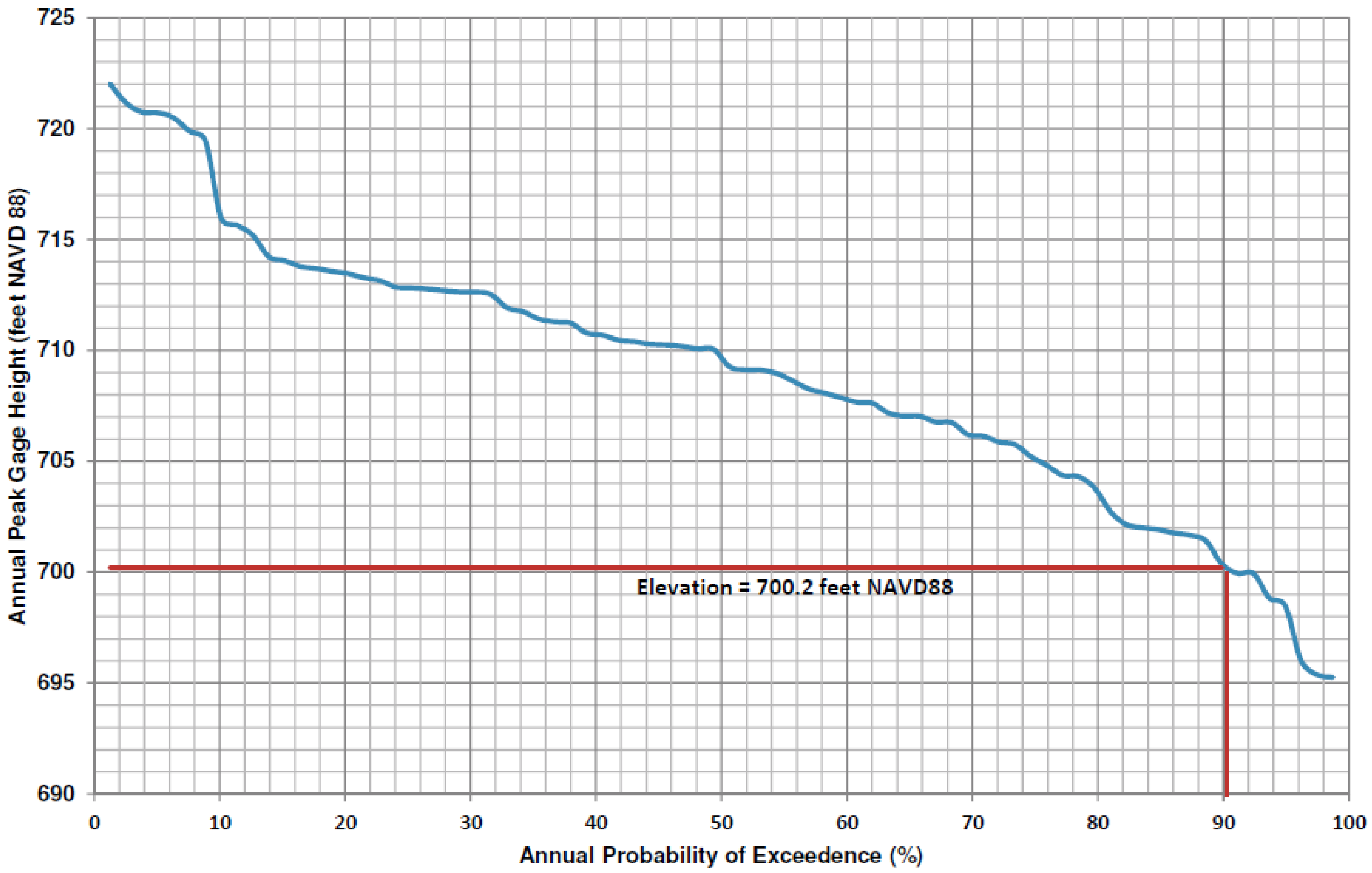
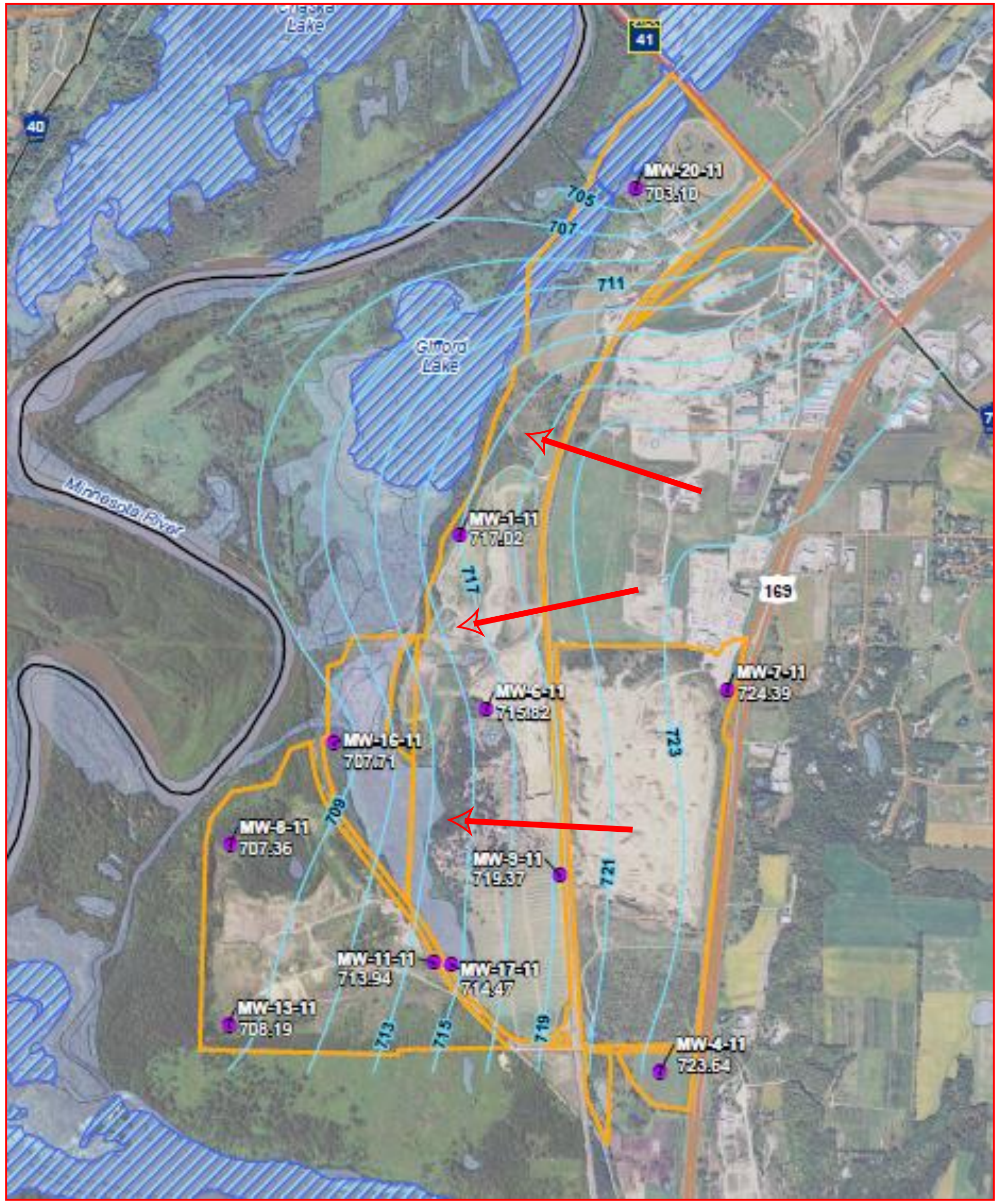
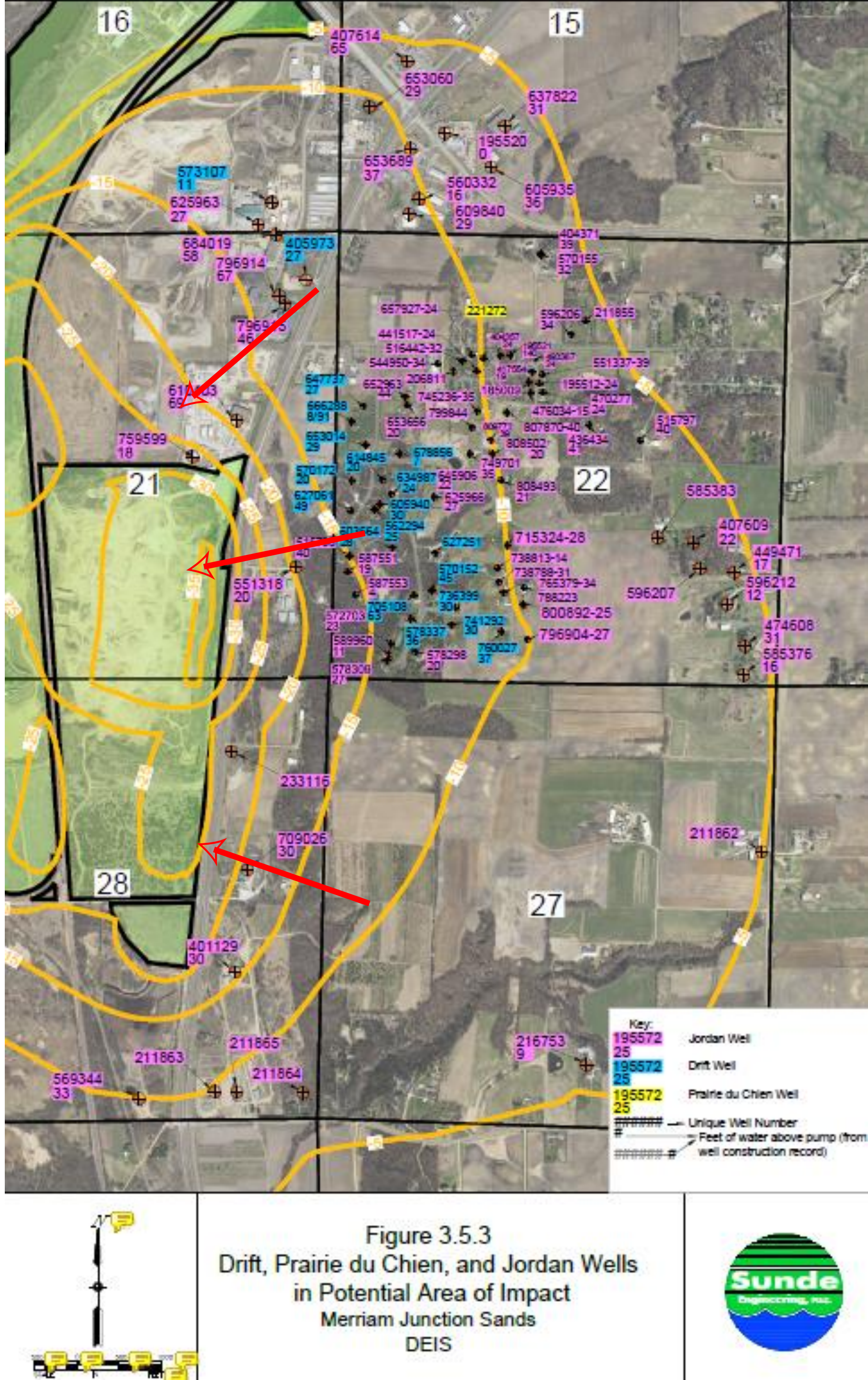


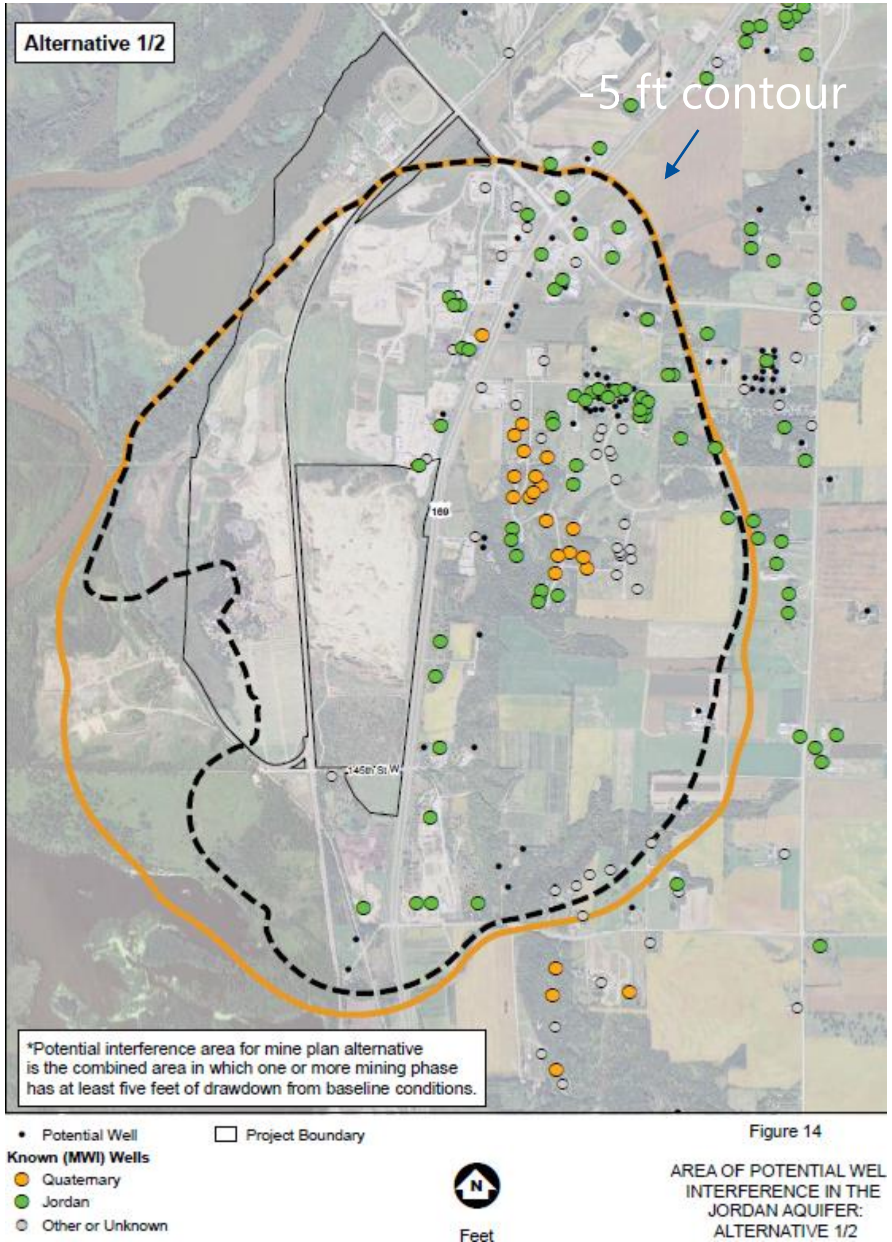
Figure 1A. Peak Stage Probability Curve for the Minnesota River near the Louisville Swamp Outlet

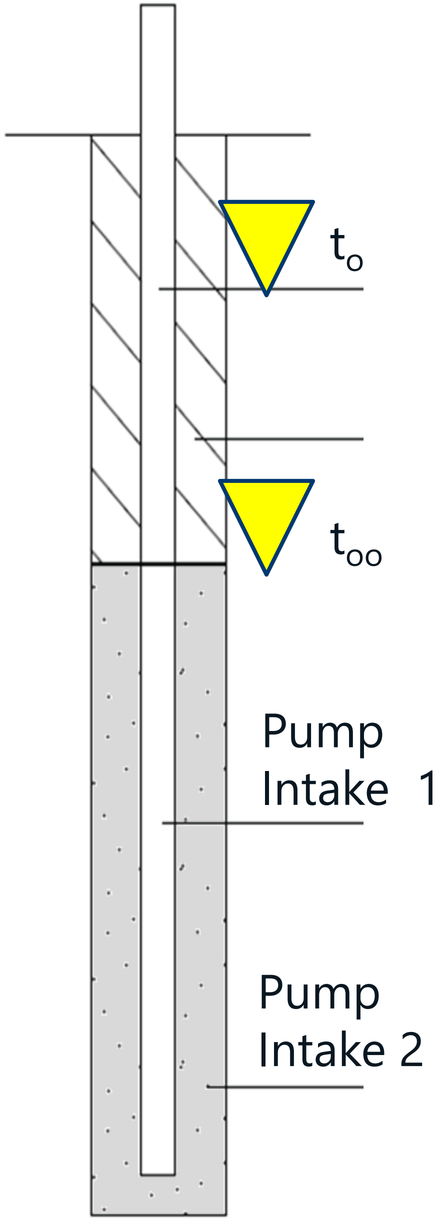
Assessing effects of dewatering on wells

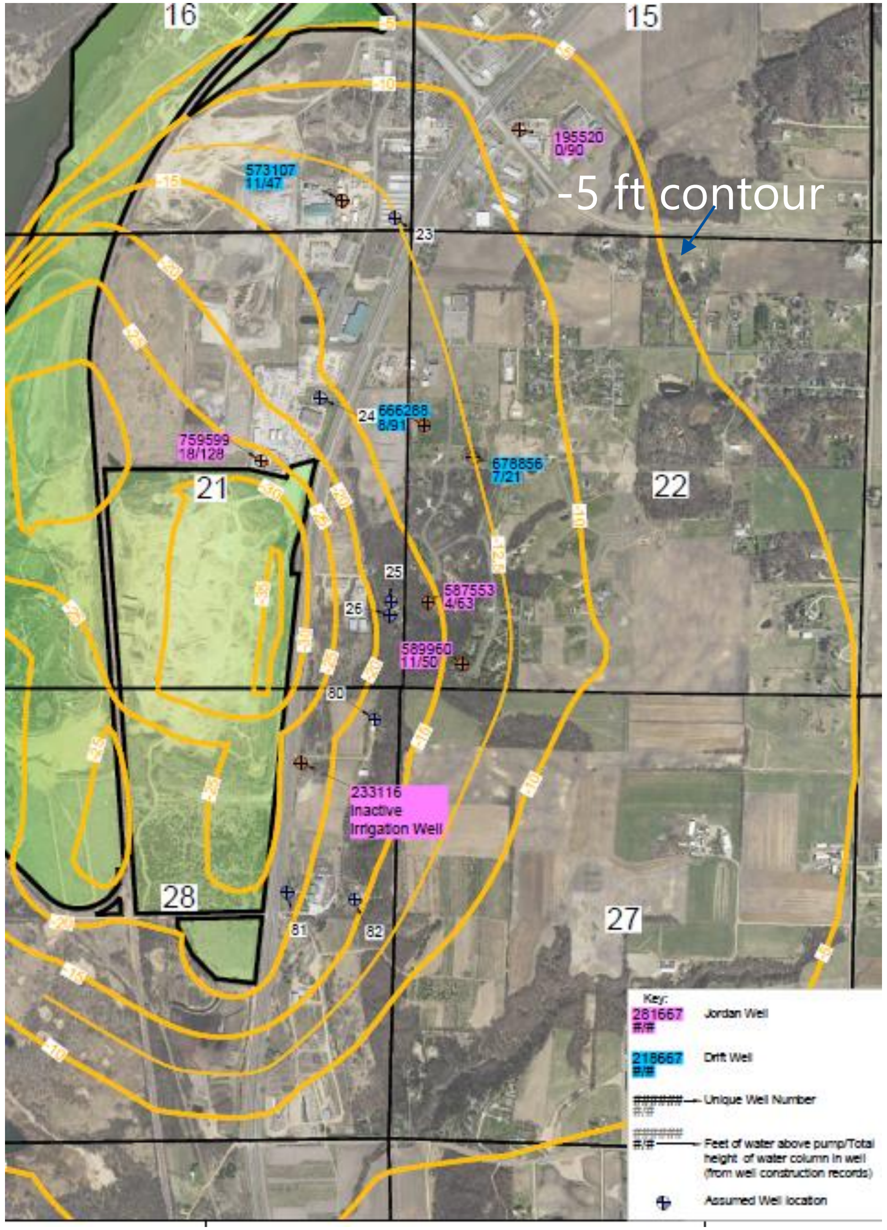




Water wells potentially effected by dewatering



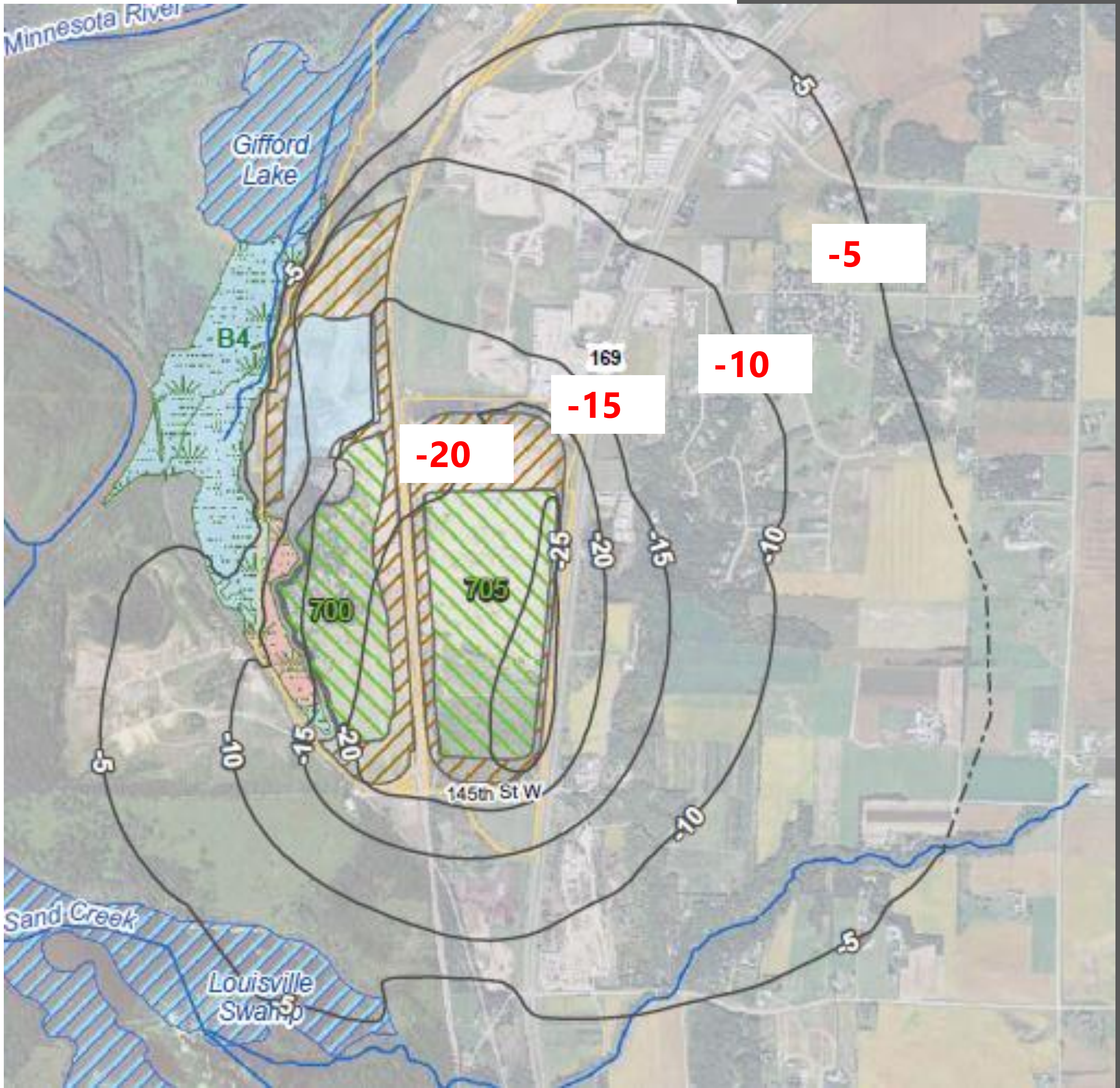




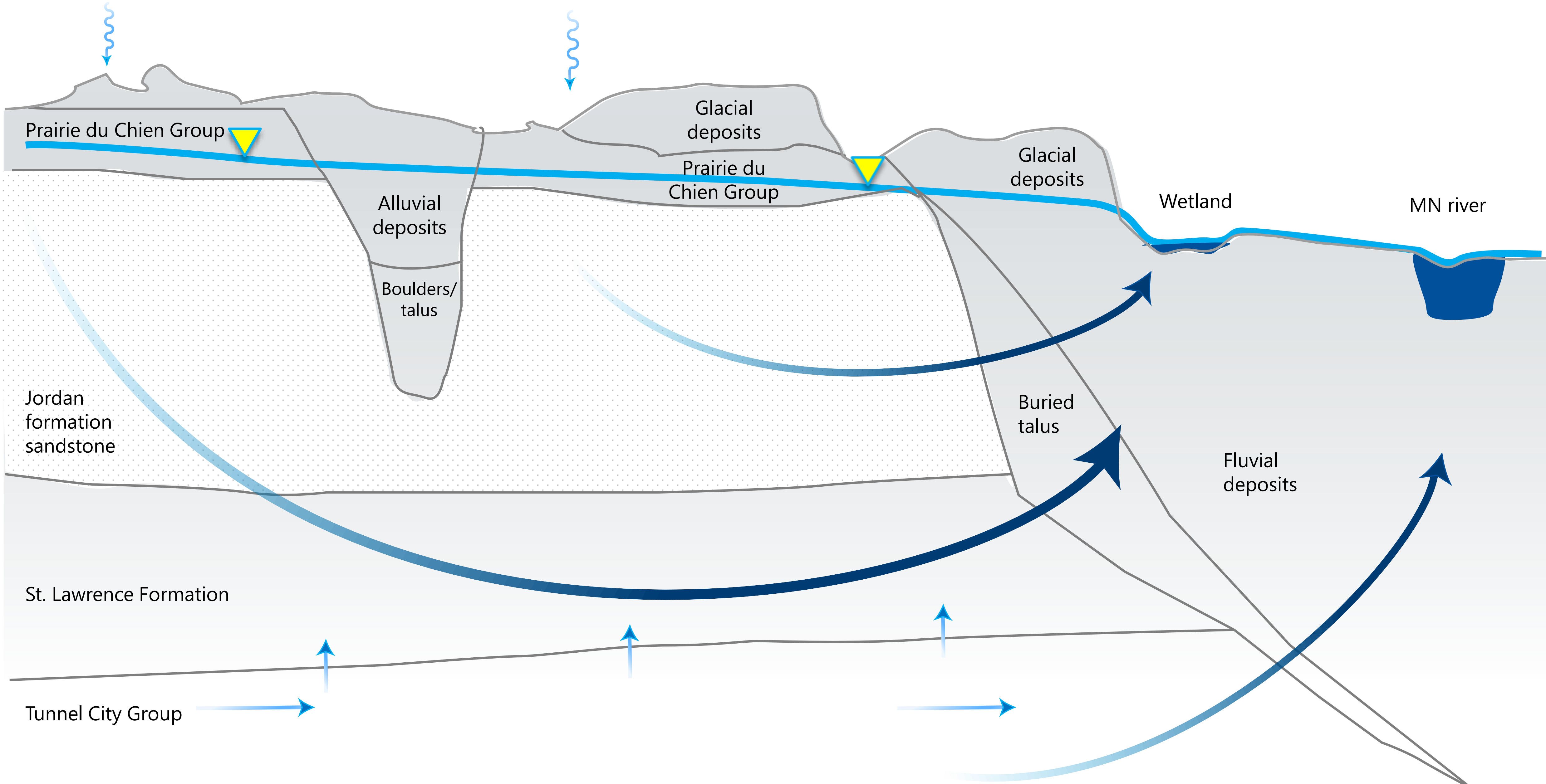
Well interference - mitigation

- Looked at drawdown during installation during yield tests
- Same depth of water column over pump intake
- If well not properly constructed before dewatering – documentation in well owner agreement
- If/when performance declines – monitoring early warning
- Reset pump, drill new well, supply water

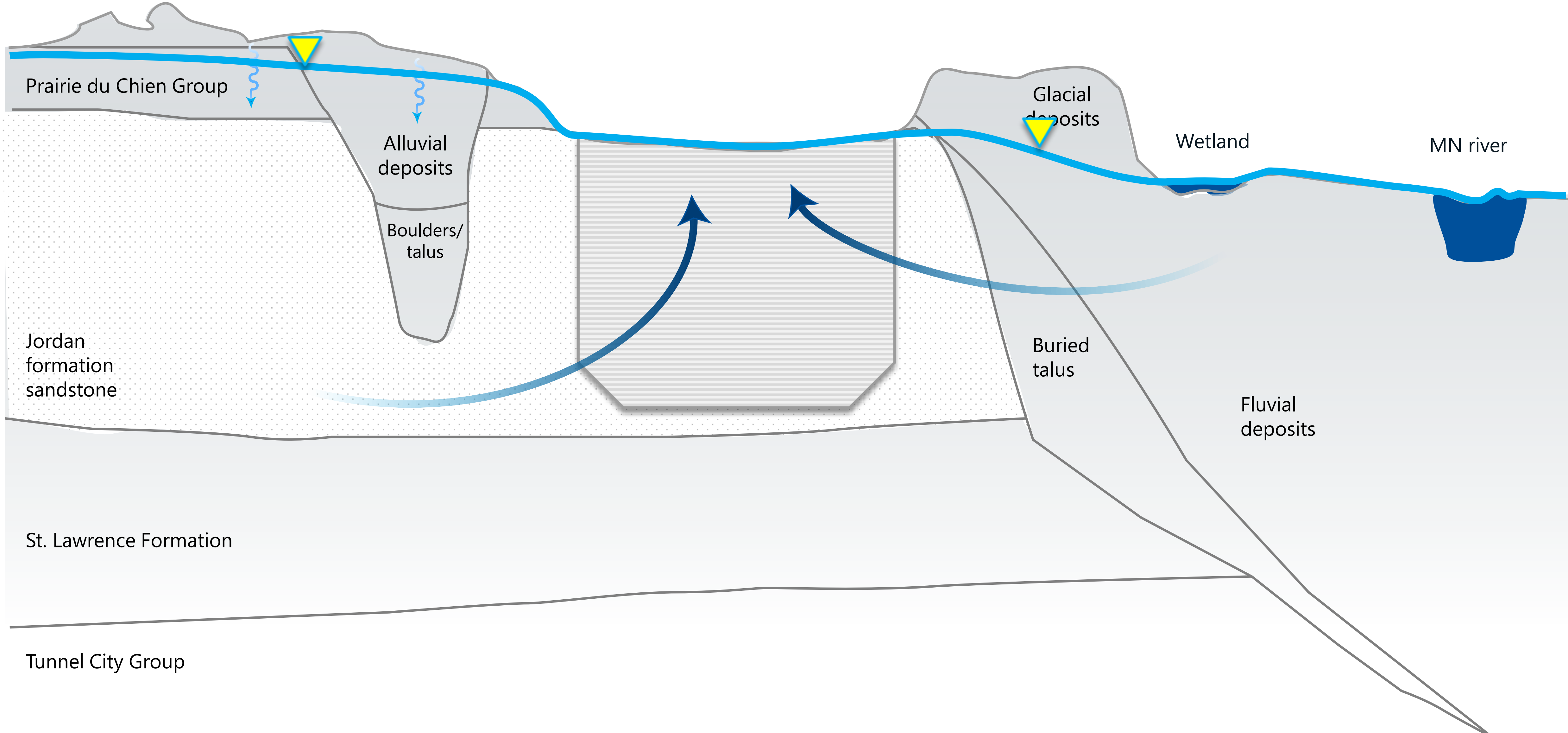
Assessing effects of dewatering on wetlands/water resources



Conceptual site model

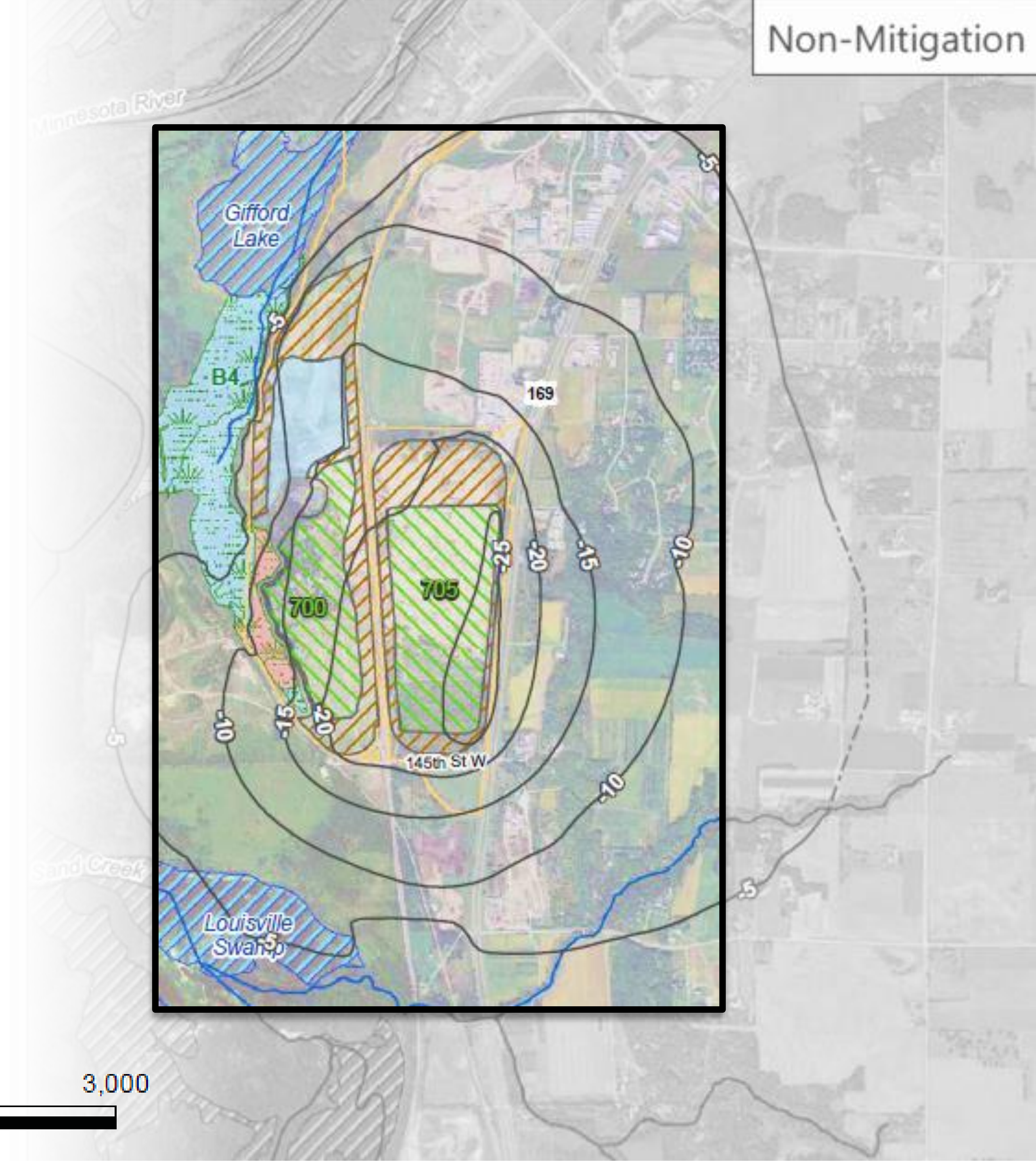


Short-circuit



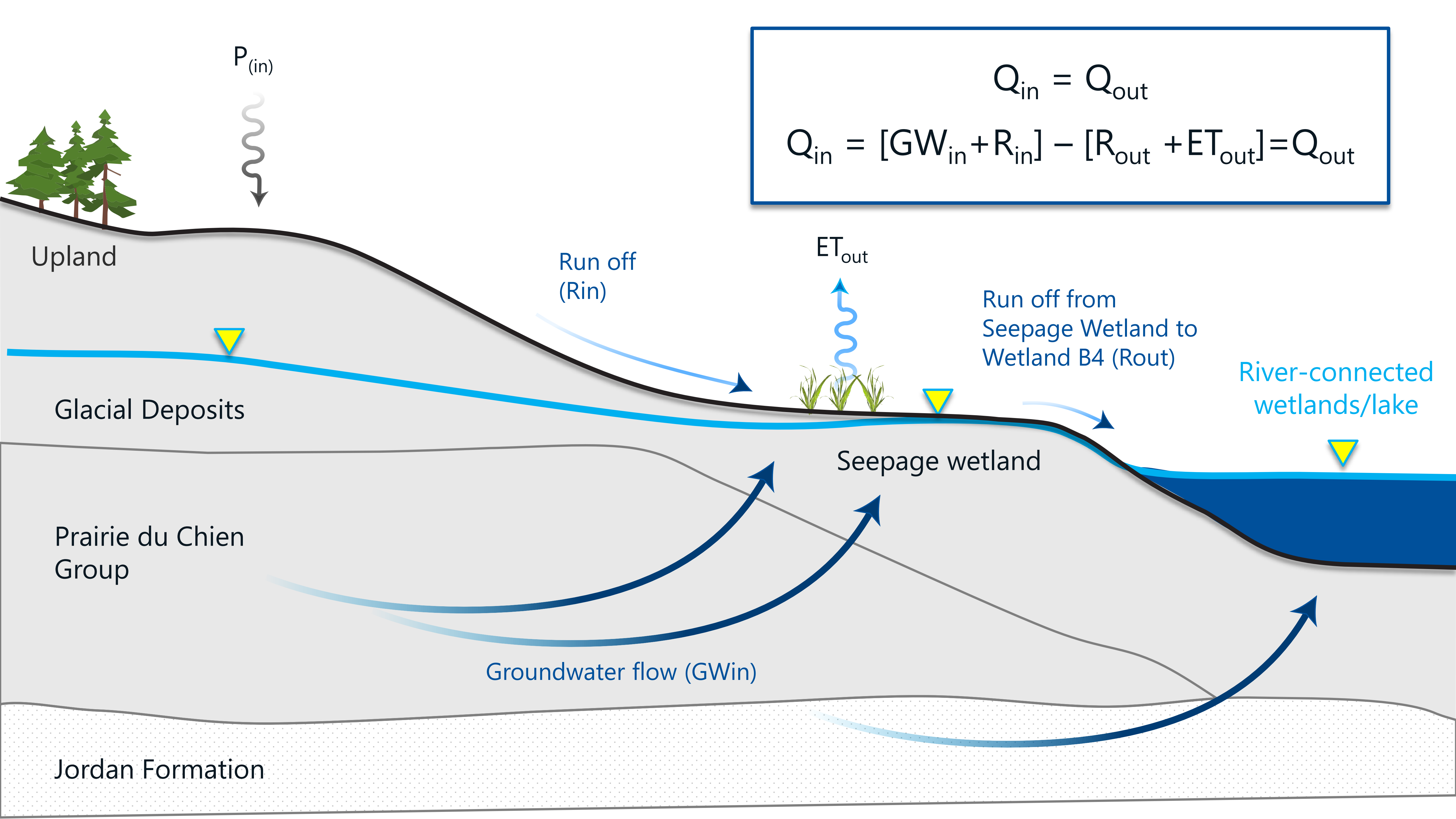
Typical approach: decline in head (“drawdown”)

- Effect: 10–15-foot decline in water table
- Discharge to wetlands is short-circuited
- Assumption: 15 feet of drawdown at wetland (“this sounds kinda bad”)
- What does it mean? RGU requested more info



“Proportional change” water balance

- Q=0 (steady state; no change in storage)
- $GW_{in}+R_{in}+SW_{in}=ET_{out}G_{out}+SW_{out}$
- Define the sources of water for each resource
- Flow in and out of each – XPSWMM (Precip included in R terms)
- Estimate groundwater term in water balance
- Excess flow is available for dewatering ($SW_{out}>>G_{in}$)
- Proportional change is the % change from dewatering x the % of GW input)



$Q_{in} = Q_{out}$
$Q_{in} = [GW_{in} + R_{in}] - [R_{out} + ET_{out}] = Q_{out}$
$P_{(in)}$
Upland
Run off
(Rin)
ET_{out}
Run off from
Seepage Wetland to
Wetland B4 (Rout)
River-connected
wetlands/lake
Glacial Deposits
Seepage wetland
Prairie du Chien
Group
Groundwater flow (GWin)
Jordan Formation

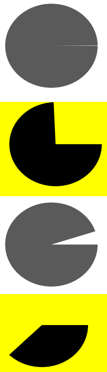
Water balance results

Table 2 Growing Season Dewatering Steady State Water Balance (Qin-Qout=0)

Feature	Qin (acre-feet)				Qout (acre-feet)			Qout available to GW without change to ET**	% of Water Balance Influenced by Dewatering***
	Precip	Sand Creek Inflow	Watershed Runoff	Groundwater (GWin)	Evapotrans (ET)	Surface Out (SWout)	Groundwater (GWout)		
Louisville Swamp	327	12,653	108	0	427	12,659	2	12,661	0%
Gifford Lake	NA	NA	217	75*	270	22	0	0	**26%**
Wetland B4***	116	NA	106	89*	152	159	0	70	6%
Seepage Wetland*	*29*	*NA*	*0*	*49*	*38*	*40*	*0*	*0*	**63%**

Table is derived from Barr (2014b) included in Appendix A.

NA This term was not used in the model dataset for this parameter or was consolidated to efficiently utilize the model dataset.

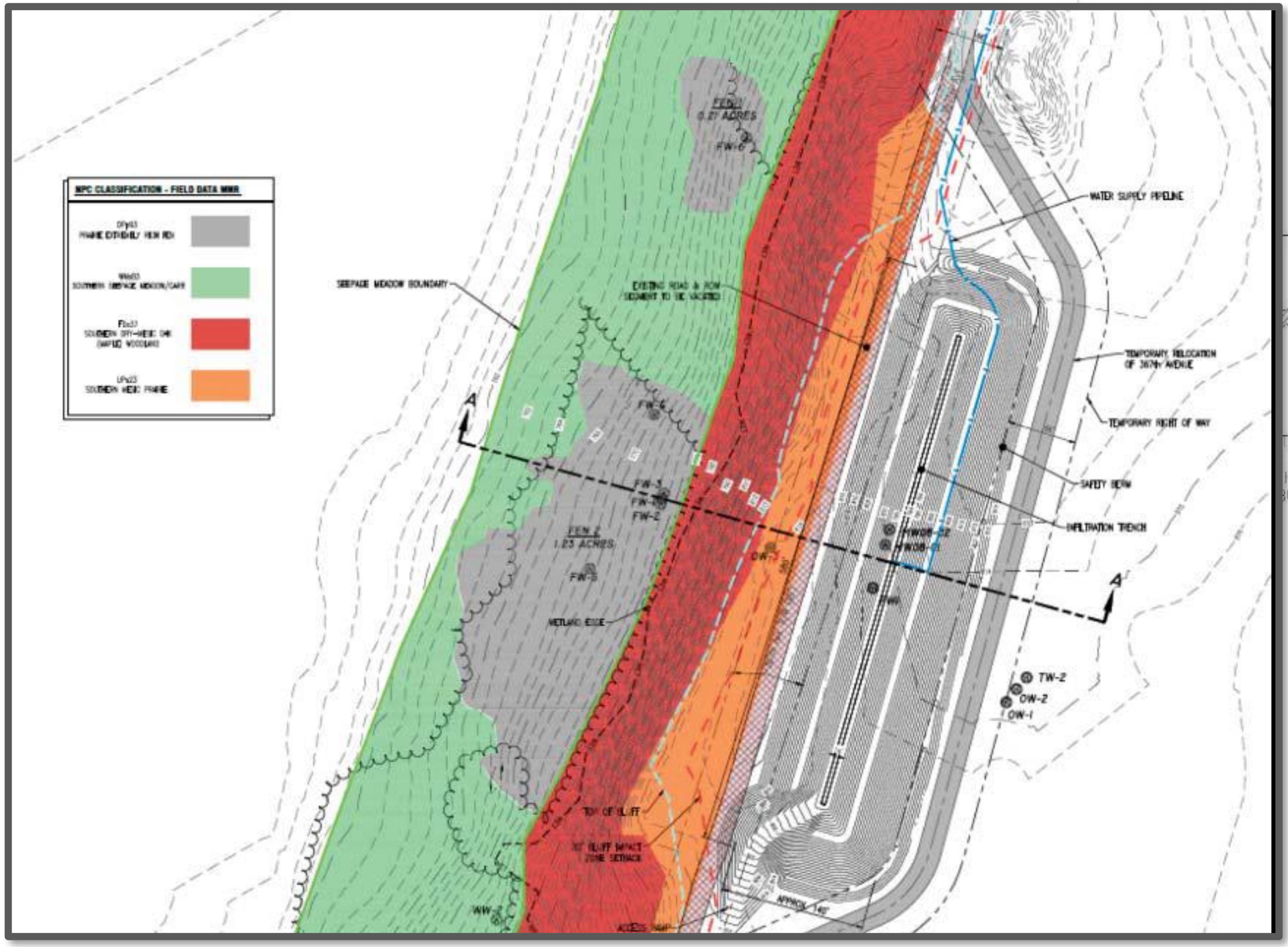


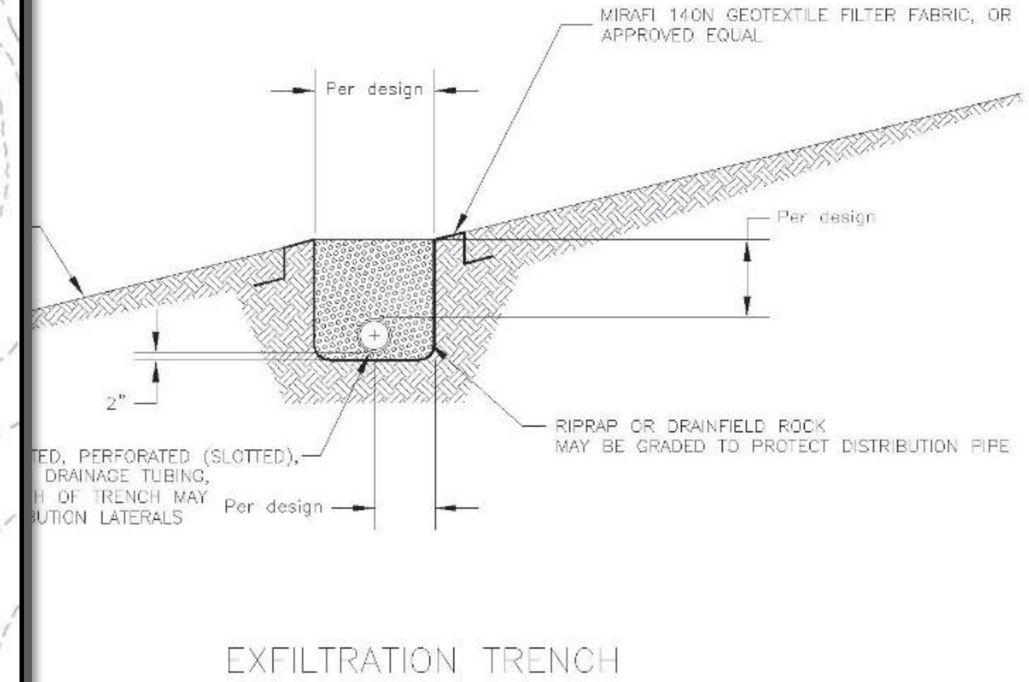
Dewatering effects on water balance

Alternative	Phase	Non-Mitigation								
			Louisville Swamp		Gifford Lake		B4 Wetland Complex		SeepageWetland	
		Estimated Pumping Rate	Simulated % Change in GW Discharge	Net Change (multiply by 0% from Table 2)	Simulated % Change in GW Discharge	Net Change (multiply by 26% from Table 2)	Simulated % Change in GW Discharge	Net Change (multiply by 6% fr. Table 2)	Simulated % Change in GW Discharge	Net Change (multiply by 63% from Table 2)
Alt 1/2	1A & 1B	3,950	- 15%	0%	- 25%	-7%	- 91%	-5%	- 100%	**-63%**
	2A & 2B	3,310	- 21%	0%	- 14%	-4%	- 81%	-5%	- 100%	**-63%**

Alt 3	2	2,960	- 16%	0%	- 12%	-3%	- 76%	-5%	- 100%	63%
	3	2,810	- 19%	0%	- 9%	-2%	- 68%	-4%	- 100%	-63%
	4A	3,240	- 21%	0%	- 10%	-3%	- 78%	-5%	- 100%	-63%
	4B	4,360	- 21%	0%	- 24%	-6%	- 91%	-5%	- 100%	-63%
Alt 4/5/6	1	2,260	- 15%	0%	- 6%	-2%	- 76%	-5%	- 100%	-63%
	2	3,600	- 17%	0%	- 22%	-6%	- 91%	-5%	- 100%	-63%
	3	3,340	- 19%	0%	- 15%	-4%	- 82%	-5%	- 100%	-63%
	4	2,940	- 20%	0%	- 12%	-3%	- 70%	-4%	- 100%	-63%
Reclamation		--	- 8%	0%	- 4%	-1%	+ 86%	5%	+ 261%	164%

Last words: Evaluating mitigation strategies





Dewatering effects with mitigation

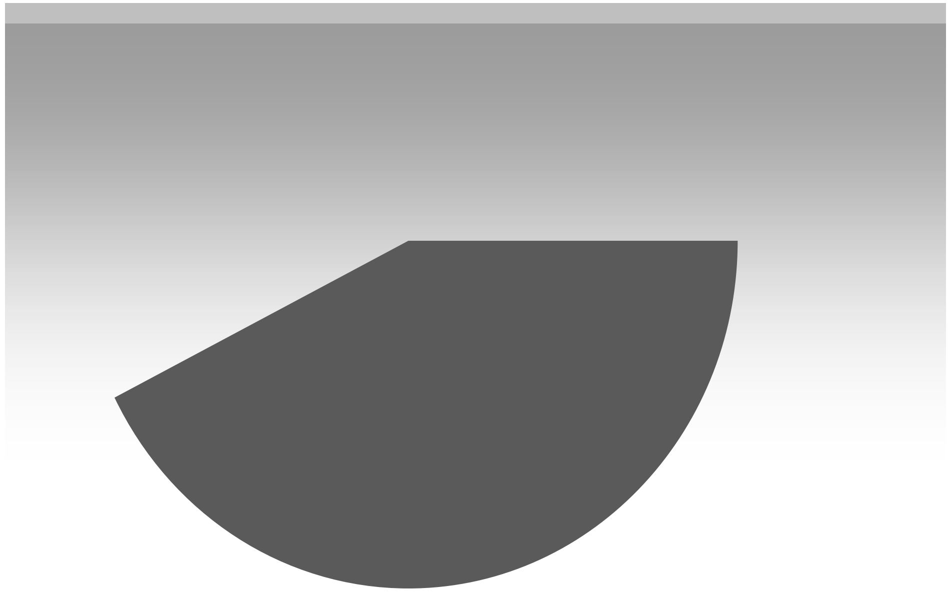
Mitigation (at 716 ft MSL									
		Louisville Swamp		Gifford Lake					
Estimated Pumping Rate	Infiltration Rate	Simulated % Change in GW Discharge	Net Change (multiply by 0% from Table 2)	Simulated % Change in GW Discharge	Net Change (multiply by 26% from Table 2)				
4,970	1,700	- 12%	0%	- 24%	-15%				
9,960	7,510	- 17%	0%	- 13%	-8%				
840	740	- 4%	0%	- 1%	-1%				
3,480	1,520	- 12%	0%	- 11%	-7%				
4,200	2,360	- 17%	0%	- 9%	-6%				
9,830	7,490	- 17%	0%	- 10%	-6%				
7,200	4,170	- 10%	0%	- 21%	-13%	- 55%	-3%	+ 33%	21%
8,980	7,580	- 10%	0%	- 6%	-4%	- 30%	-2%	+ 28%	18%
6,850	4,480	- 5%	0%	- 20%	-13%	- 55%	-3%	+ 34%	21%
5,570	4,120	- 12%	0%	- 10%	-6%	+ 14%	1%	+ 79%	50%
5,400	3,980	- 17%	0%	- 9%	-6%	+ 20%	1%	+ 83%	52%
--	--	- 8%	0%	- 4%	-1%	+ 86%	5%	261%	164%

SeepageWetland	
Simulated % Change in GW Discharge	Net Change (multiply by 63% from Table 2)
+ 48%	30%

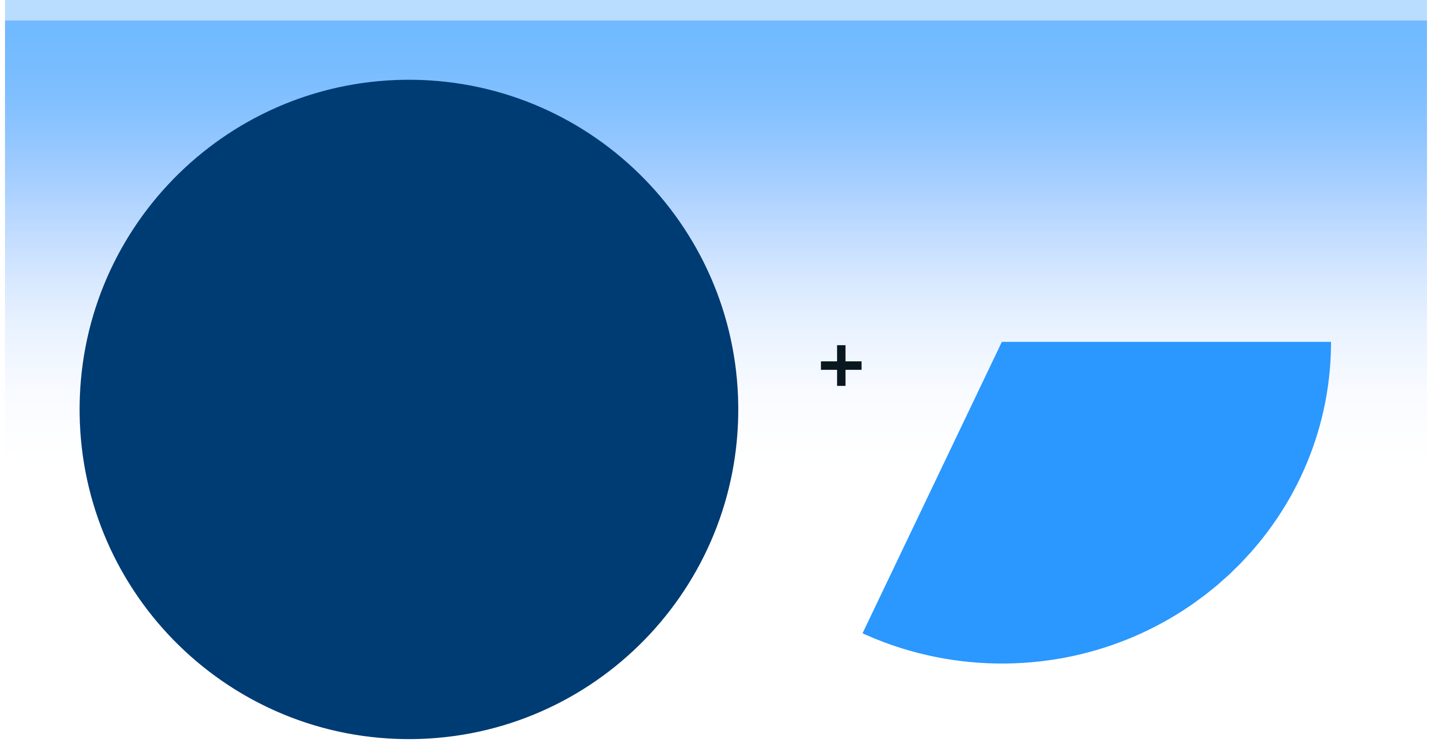
Proportional change in water balance for seepage wetland

"Generally speaking, an abundance of water is not necessarily a bad thing if you are a wetland"
– Daniel Tix, PhD (Botanist/Wetland Ecologist)

Without mitigation



With mitigation



Up 30% of additional GWin from discharge can be added if necessary

Summary

- Not all potential environmental effects are "significant" in the context of MN Rules Chapter 4410
- Stakeholders tend to assume that any effect has an impact
- Model forecasts of water table decline from the "baseline" can be confusing at water bodies/wetlands
- Results more straightforward in addressing impact to wells from project
- Using water balance method allows for clarity in understanding the change in flux to water bodies-potential effects more tangible
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Questions?

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